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(71) Applicant  
**Magnaghi Milano S.p.A**

(Incorporated in Italy)

Via Stamira d'Ancona 27, Milano, Italy

(72) Inventor  
**Costantino Tovagliaro**

(74) Agent and/or Address for Service  
**Raworth Moss and Cook**  
 36 Sydenham Road, Croydon, Surrey, CR0 2EF,  
 United Kingdom

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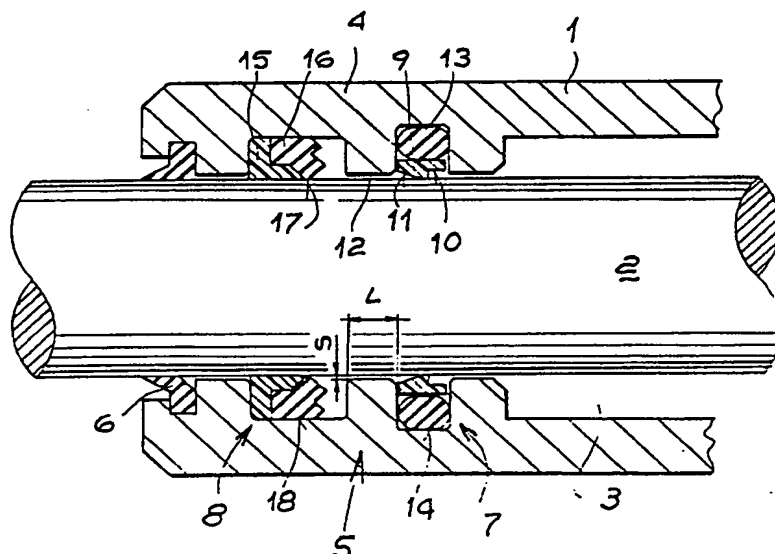
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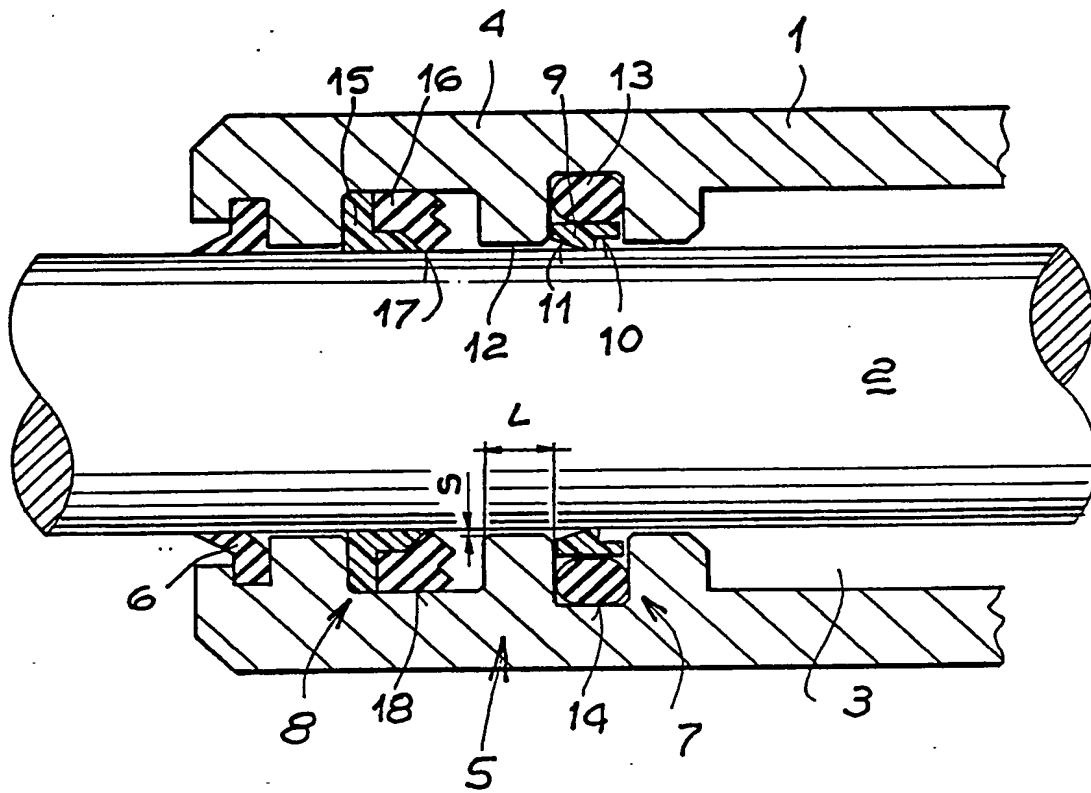
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**(54) Fluid-tight sealing assembly for axially slidable cylindrical coaxial parts**

(57) A fluid-tight sealing assembly for the rod (2) of a hydraulic actuator is axially slidable inside a passage of a fixed outer body (1), between a chamber (3) at high pressure and an external environment at low pressure, comprising a first composite seal (7) nearer the chamber at high pressure, with a sealing part (9) sliding on the external surface of the rod and consisting of a ring made of plastics material with a low coefficient of friction, forming a step (10) towards the chamber at high pressure, and surrounded by a toroidal seal (13) made of elastomeric material providing a static seal and radial clamping. The whole is housed in a corresponding seat (14) in the outer body (1), followed by a second composite seal (8), nearer the outside, with a sealing part sliding on the rod and consisting of a ring (16) made of an elastomeric material with an angled sealing lip (17) in contact with the surface of the rod, coupled to a ring (15) made of plastics material with a low coefficient of friction, housed in a corresponding seat (18) in the outer body, with the angled sealing lip (17) turned towards the first seal (7). The seals are axially spaced and an annular chamber (12) is formed between them.





FLUID-TIGHT SEALING ASSEMBLY FOR AXIALLY SLIDABLE  
CYLINDRICAL COAXIAL PARTS

5 The present invention relates to a fluid-tight sealing  
assembly for axially slidable cylindrical coaxial parts.

10 Hydraulically operated linear actuators are widely used  
for the operation of servocontrol units, particularly in  
the case of aeronautical applications. Such actuators,  
generally consisting of a cylinder and piston assembly,  
are required to perform, in the course of their use, a  
fairly high number of movements of extension and  
retraction through distances varying according to the  
commands received.

15 For example, the actuators responsible for the movement of  
the control surfaces of aircraft are required continually  
to correct the trim of the surfaces according to the  
commands issued by the pilot, by making a very large  
20 number of movements.

25 In such devices, frequently operating at high pressures,  
it is necessary to ensure complete fluid-tightness,  
particularly of the piston rod where it passes to the  
outside, avoiding leaks of hydraulic fluid while ensuring  
a prolonged service life of the seals used for this  
purpose.

30 Seals with various configurations and materials are known;  
among these are seals with a sliding sealing part, in  
contact with the moving part of the actuator, and  
consisting of a ring made of an elastomeric material

supported by a reinforcing ring made of a plastics material of a substantially rigid type; other seals have a sliding sealing part made of a substantially rigid plastics material with a low coefficient of friction, such as polytetrafluoroethene (PTFE), radially clamped to the moving part of the actuator by a ring made of elastomeric material.

Seals of the first type mentioned, with a sliding sealing part made of an elastomeric material, are capable of providing fluid-tightness with practically no leaks; however, in order to provide the requisite fluid-tightness at high pressures, such seals must be radially clamped to the surface of the moving part of the actuator with a force which, as a result of friction, produces a considerable resistance to the motion of the moving part and also causes rapid wear.

Seals of the second type offer a low resistance to the sliding motion, even in the presence of high fluid pressures; however, owing to the rigidity of the plastics material used for the part subject to sliding, they do not provide complete tightness, resulting in leaks of fluid to the outside which cannot be totally eliminated in practice.

It has been proposed that seals arranged sequentially should be used, in such a way as to divide the whole pressure drop into two or more drops of smaller size; however, such known sealing assemblies, if using two seals with sealing parts made of "rigid", low-friction, plastics material, do not totally eliminate leaks, particularly in the most demanding applications as found in aeronautical use.

Sealing assemblies are also known which have an inner sealing part made of a substantially "rigid" plastics material, capable of producing a reduction in pressure, and an outer sealing part made of an elastomeric material which is capable of creating a seal without leaks if exposed to the limited pressures resulting from the action of the inner part; however, with successive operating cycles, such sealing assemblies tend rapidly to bring the space between the external sealing part made of elastomeric material and the internal sealing part made of "rigid" material to the same pressure as the maximum pressure to be intercepted, and consequently require the provision of drainage channels for this space, leading to a collecting vessel for the leaked fluid, in order to maintain in the space a fluid pressure level intermediate between the pressure of the internal fluid and the pressure external to the actuator, and this construction is complex and burdensome.

Seals are known which comprise a sealing ring made of plastics material of the rigid type, having a step of the surface in contact with the moving part, facing the internal, pressurised chamber of the actuator, and an oblique surface flared in the direction of the outside of the actuator, radially clamped to the moving part by a toroidal ring; such seals, hereinafter called step seals for the sake of brevity, are described in the publication "ENERGIE FLUIDE", No. 3, April 1983, pp. 48-53, by H.K. Mueller, in "Optimisation de garniture d'étanchéité de tiges" (Optimisation of rod seals) and have been marketed by W.S. Shamban & Co., Newbury Park, California, USA, under the registered trademark STEPSEAL.

The step seals of the type indicated provide a particularly low level of friction and good tightness under pressure, but are also subject to leakage of fluid in particular conditions of use.

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The publication cited above also proposes the use of two step seals in succession or in "tandem"; such a construction is, as described in the publication, satisfactory for many uses, but in particular severe conditions, such as, in particular, the previously cited case of aircraft servocontrols, it does not solve the problem of providing tightness without leaks together with low sliding friction.

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It is therefore necessary, particularly for applications which are particularly demanding or delicate, as in the case of servo actuators for aeronautical use, to provide a sealing device which has the said characteristics of tightness and low sliding friction.

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According to the present invention, there is provided a fluid-tight assembly for coaxial cylindrical and axially relatively slidable parts comprising a rod sliding in a passage in an outer fixed body, between a high pressure chamber, formed between the rod and the outer body, and an environment external to this, at low pressure, the assembly including a first composite seal provided, nearer the high pressure chamber, with a sealing part sliding on the external surface of the rod, consisting of a ring made of a plastics material with a low coefficient of friction, forming a step facing the high pressure chamber, surrounded by a toroidal seal made of

elastomeric material, forming a static sealing part and radial clamp, the whole being housed in a corresponding seat in the outer body, followed by a second composite seal, nearer the outside, with a sealing part sliding on the rod and consisting of a ring made of plastics material with a low coefficient of friction, coupled to a ring made of elastomeric material with an angled sealing lip in contact with the surface of the rod, housed in a corresponding seat in the outer body, with an angled sealing lip nearer the first seal, the seals being axially spaced and with an annular chamber formed between them and between the external surface of the rod and the surface of the passage in the outer body.

Preferably, the radial play between the external surface of the rod and the surface of the passage in the outer body, defining the volume of the annular chamber at lower pressure, should be more than 1/10 mm and the seals should be spaced axially at a distance of 1 to 5 times the overall axial dimension of the smaller seal.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which the single Figure shows in schematic form a rod of a hydraulic actuator projecting from its cylinder, in axial section, with sealing devices.

As shown in the drawing, a cylinder 1 of a hydraulic actuator has an axially movable rod 2 projecting to the outside, to which are attached the devices operated by the actuator.

The cylinder 1 has a chamber 3 surrounding the rod, to which hydraulic fluid under pressure is supplied for the operation of the actuator; this chamber is bounded towards the outside by an end 4 having a passage through which passes the rod 2, in which passage a sealing assembly 5 is located; this assembly is capable of preventing the fluid under pressure from passing to the outside, both in static conditions and during the movement of the rod. If necessary, a lip seal 6 also prevents the penetration of dust and foreign bodies from the outside to the sealing assembly.

The sealing assembly 5 consists of two seals arranged sequentially; these seals consist of a step seal 7, with a part made of a substantially rigid plastics material in contact with the rod, and with a low coefficient of friction, nearer the interior of the cylinder 1, and a composite lip seal made of elastomeric material 8 nearer the outside.

In greater detail, the seal 7 consists of an inner ring 9 made of rigid plastics material with a low coefficient of friction, such as polytetrafluoroethene (PTFE) or similar, sliding against the surface of the rod 2, which when seen in section, as in the drawing, has a step 10 facing the chamber 3 containing the fluid under pressure, and an oblique surface 11 facing the space 12 between the seal 7 and the seal 8.

Outside the ring 9 there is a toroidal seal 13 made of an elastomeric material, providing a static seal between the external surface of the ring 9 and the internal surface

of the annular cavity 14 of the cylinder end 4, inside which the seal is housed, and also providing the radial clamping force on the ring 9 which ensures its tightness.

5       Seals of this kind are commercially available; for example, a suitable seal of this kind is that bearing the registered trademark "STEPSEAL" produced by W.S. Shamban & Co.

10       The seal 8 consists of a ring 15 made of low-friction plastics material, such as polytetrafluoroethene (PTFE) or similar, with a substantially L-shaped section, coupled with a ring, 16, made of elastomeric material, having an angled sealing lip 17 against the surface of  
15       the rod, and facing the region of higher pressure, in other words the region 12.

The seal 8 is housed in a corresponding annular cavity 18 of the cylinder end 4.

20       Seals of this kind are commercially available; for example, a suitable seal of this kind is that bearing the registered trademark "HATSEAL" produced by W.S. Shamban & Co.

25       Between the seal 7 and the seal 8 there is a distance "L" in the axial direction which may conveniently be between one and five times the overall axial dimension of the smaller seal; this has the purpose of giving the annular  
30       chamber 12 a volume such that a pressure lower than that in chamber 3 is produced in it, and that this level is kept constant in the course of successive operating cycles of the actuator.

The volume of the chamber 12 is also determined by the radial play "s" between the rod 2 and the passage in the cylinder end. 4, within which it slides; this play may conveniently be greater than 1/10 mm, and consequently it is unnecessary for the passage to be machined with very high precision.

The seal 7 is of the type which can withstand very high pressures and which offers fairly low frictional resistance to the sliding of the rod; because of the characteristics of the material forming the ring 9 however, this allows a degree of loss by leakage, which, although limited, is unacceptable for aeronautical use.

The seal 8 in turn, provides complete tightness, without leaks, because of its lip made of elastomeric material 17 elastically clamped to the surface of the rod 2; however, this causes low friction only if the clamping force is not excessive, and this requires that the pressure acting on it should be as low as possible.

The present assembly therefore provides, by means of the seal 7 a pressure in the region 12 considerably lower than that present in chamber 3; the seal 8 can effectively withstand this pressure with reduced friction while providing complete tightness.

The characteristics of the seal 7, which constantly maintains a pressure difference between the chamber 3 and the region 12, in the presence of movements of the rod 2, make it possible to avoid the provision of a complicated system of drainage ducts for the region 12, which are

required with seals of a different type arranged consecutively, to drain off the fluid which, in the absence of drainage, would progressively accumulate in this intermediate space until the pressure was raised to the same level as that in chamber 3, which pressure level would have to be withstood by the outer seal alone after a certain time.

The arrangement of the present sealing assembly is therefore particularly advantageous and superior to the known devices which do not specify any kind of coupling.

The dimensions of the seals and of the corresponding housing cavities, their distance, the size of the play between the rod and the corresponding passage in the cylinder end, etc., may be found from the known art and are therefore not described in greater detail.

Sealing assemblies for pistons or other applications, based on the same solution, may be specified in a way similar to that described above for sealing between the rod and the end of the cylinder.

CLAIMS:

1. A fluid-tight assembly for coaxial cylindrical and axially relatively slidable parts comprising a rod sliding in a passage in an outer fixed body, between a high pressure chamber, formed between the rod and the outer body, and an environment external to this, at low pressure, the assembly including a first composite seal provided, nearer the high pressure chamber, with a sealing part sliding on the external surface of the rod, consisting of a ring made of a plastics material with a low coefficient of friction, forming a step facing the high pressure chamber, surrounded by a toroidal seal made of elastomeric material, forming a static sealing part and radial clamp, the whole being housed in a corresponding seat in the outer body, followed by a second composite seal, nearer the outside, with a sealing part sliding on the rod and consisting of a ring made of plastics material with a low coefficient of friction, coupled to a ring made of elastomeric material with an angled sealing lip in contact with the surface of the rod, housed in a corresponding seat in the outer body, with an angled sealing lip nearer the first seal, the seals being axially spaced and with an annular chamber formed between them and between the external surface of the rod and the surface of the passage in the outer body.

2. An assembly according to claim 1, wherein the radial play between the external surface of the rod and the surface of the passage in the outer body, defining the volume of the annular chamber at lower pressure, is greater than 1/10 mm.

3. An assembly according to claim 1 or 2, wherein the two seals are spaced apart axially by a distance between one and five times the overall axial dimension of the smaller seal.

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4. A fluid-tight sealing assembly, substantially as hereinbefore described with reference to the accompanying drawing.

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